Influence of longitudinal reinforcement and stiffeners on strength and behaviour of 3D wall panels under axial compression

By

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INTRODUCTION

- *Precast and Prefab Structures will have significant role in infrastructure development.*
- *3D wire panel a unique and effective material to create a strong insulated concrete systems.*
- *For residential, commercial, institutional multi-storeys.*
- *Strength of 3D system is enormous and is attributed to truss wires welded to connect each side of mesh.*
- *Insulation in the center of panel is suspended on truss wires and becomes a continuous thermal break when panels are connected.*
- *Monolithic structure with 3D wire panel enables it to withstand earthquakes, hurricanes and typhoons.*

What is 3D Steel Wire Panel?

Components of panel

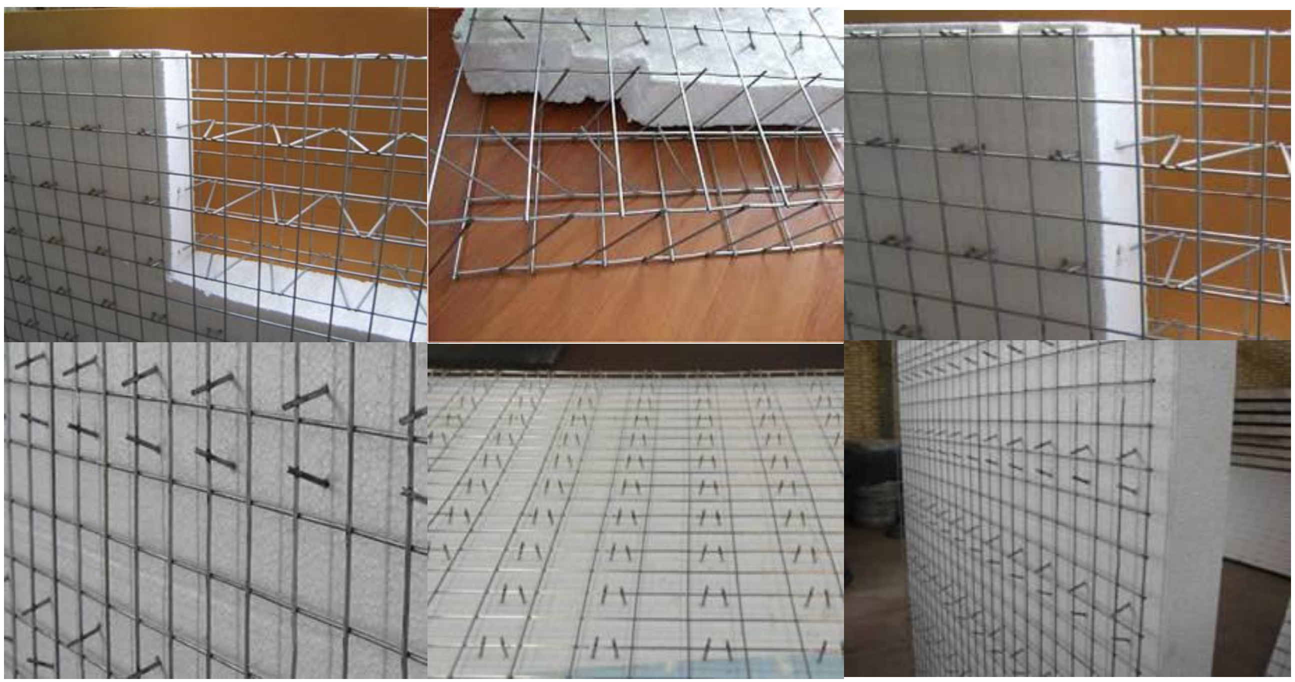
a) EPS (Expanded Polystyrene) core for insulation

b) Wire mesh on inside and outside.

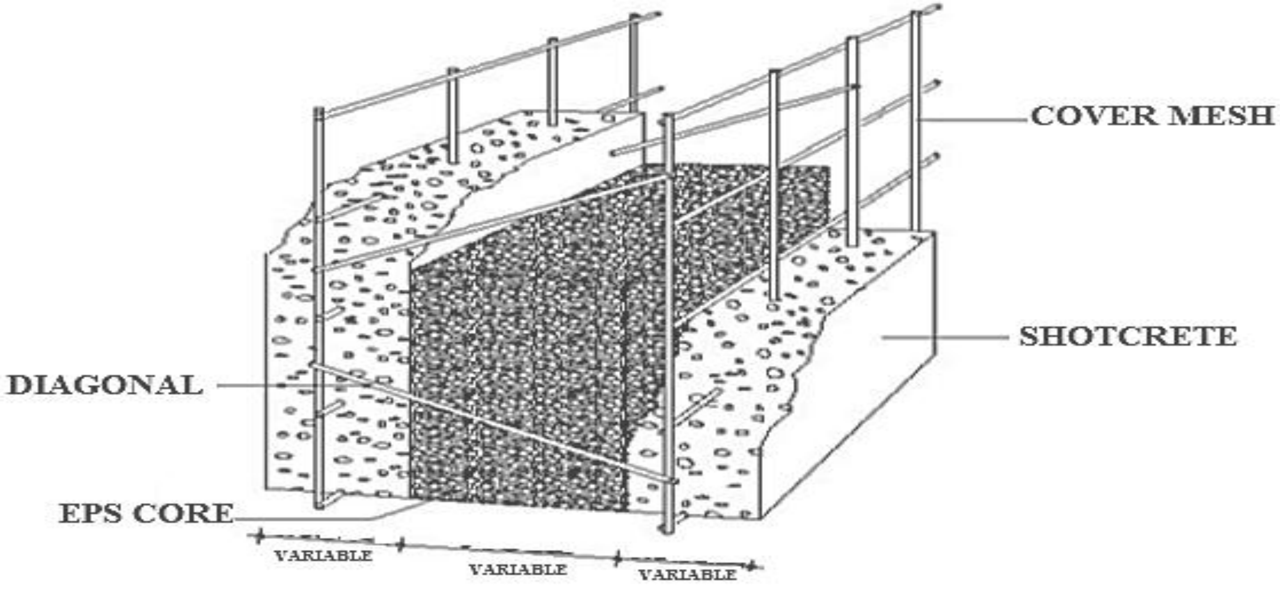
c) Welded truss of wire cross pieces.

d)Sprayed concrete on both sides ("shotcrete") or manual concreting. These panels are 4 feet wide and come in almost any length.

3D Panel



- ***3D Panel - An alternative building material***
- ***3D panels - Structural members (wall, slab, beam, etc.)***
- ***Unlike other building systems.***
  - ***Saves construction time***
  - ***Eco-friendly***
  - ***Leads to sustainable development***
- ***Behavior of such elements needs to be investigated through experiments.***



3D Cross Section (Beard sell Limited)

Benefits of 3D Panels

1. *Thermal Insulation*
2. *Fireproofing*
3. *Moisture Proofing*
4. *Soundproofing*
5. *Lightweight*
6. *Structure*
7. *Variety*
8. *Economic Efficiency*
9. *Shortening of Construction Time*

ACI EMPIRICAL WALL DESIGN METHOD

ACI 318-89 wall design equation

$P_u = 0.55\phi f_{cu} A_c [1 - (kH/32t)^2]$ ---- (1)

ACI 318-89 is applicable for walls restrained at the top and bottom with H/t ≤ 25 or L/t ≤ 25, whichever is less for load-bearing walls

Where A_c is the gross area of wall panel section (assumed equal to the gross concrete area);

f_{cu} is characteristic cube strength of concrete;

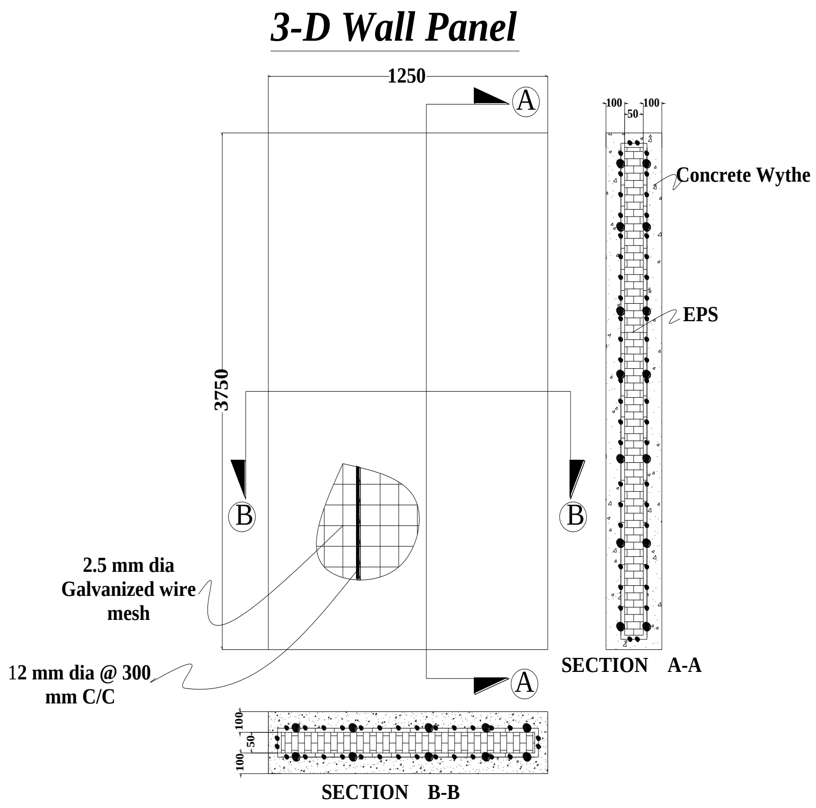
H is the effective height;

k = 0.8 for walls restrained against rotation; = 1.0 for walls unrestrained against rotation;

L is the width of the panel; t is the thickness of the panel section; and

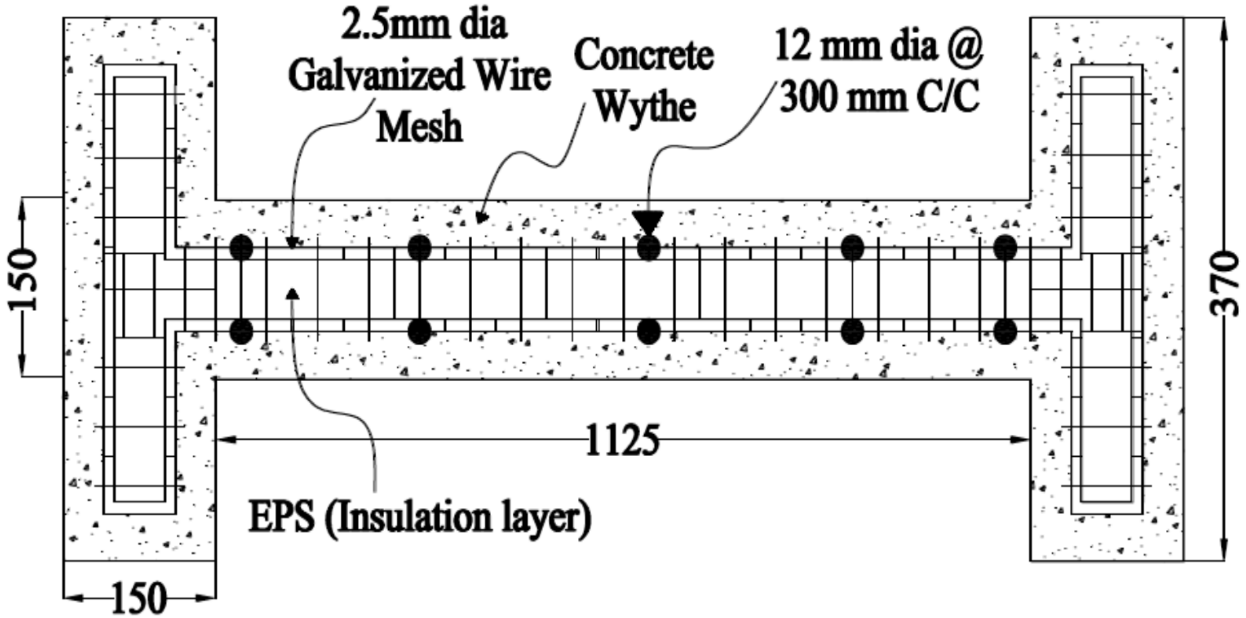
ϕ = 0.7 for compression members.

EXPERIMENTAL CAMPAIGN



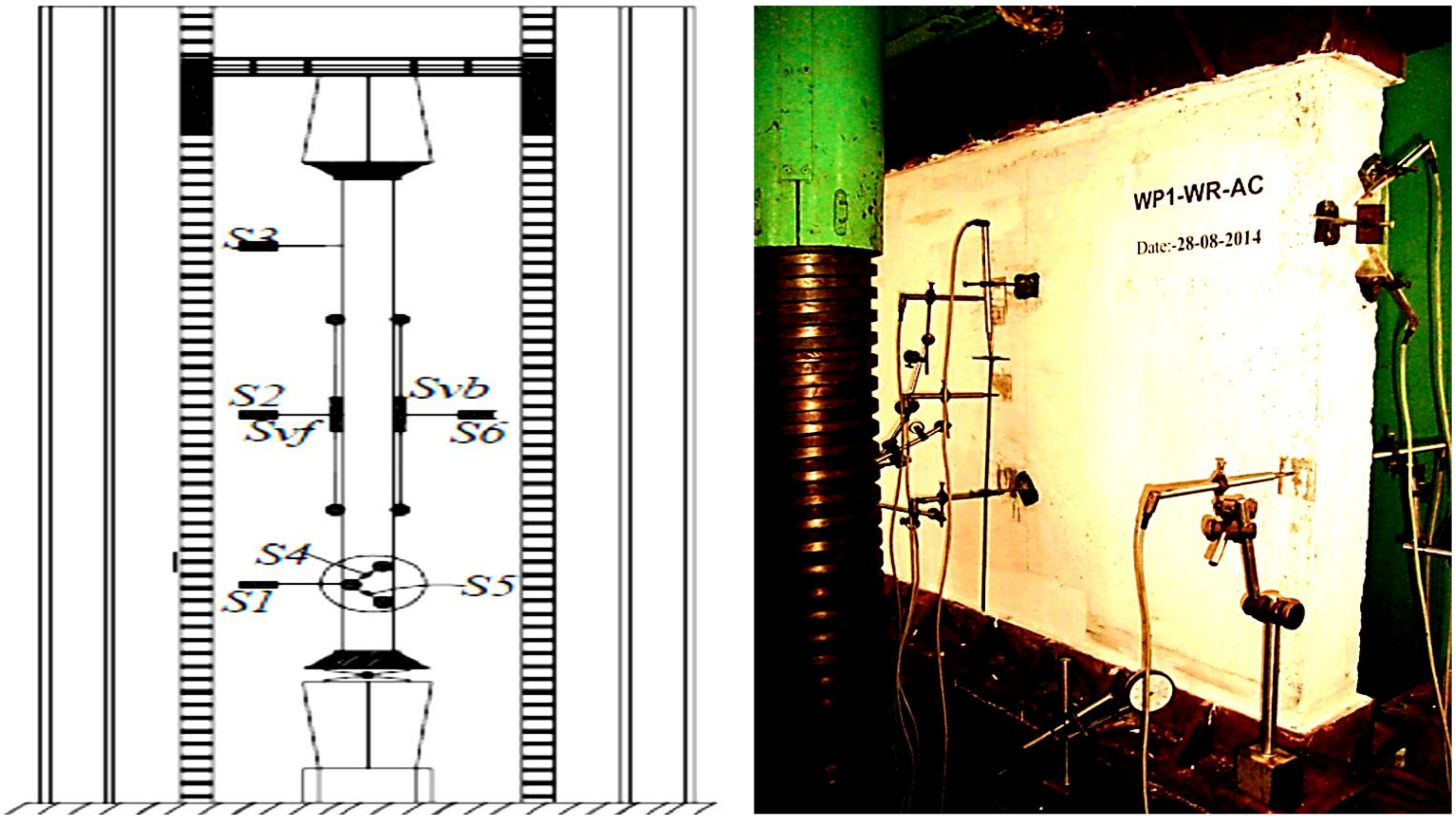
Typical 3D plain sandwich wall panel

Casting of 3D sandwich wall panel



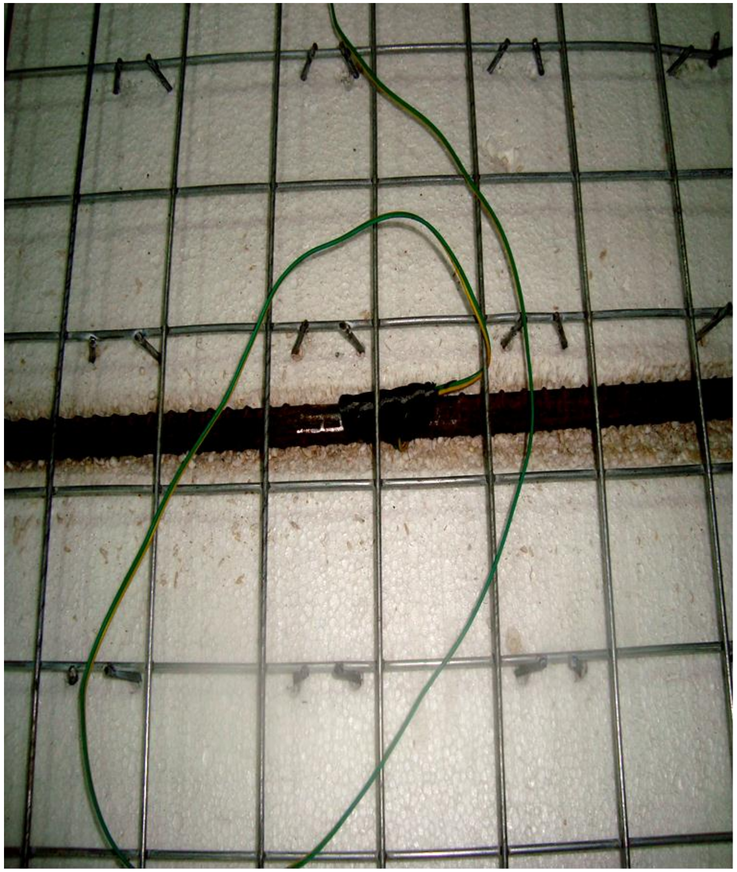
Plan, and cross sectional view of 3D sandwich stiffened panel

Instrumentation and Measurements

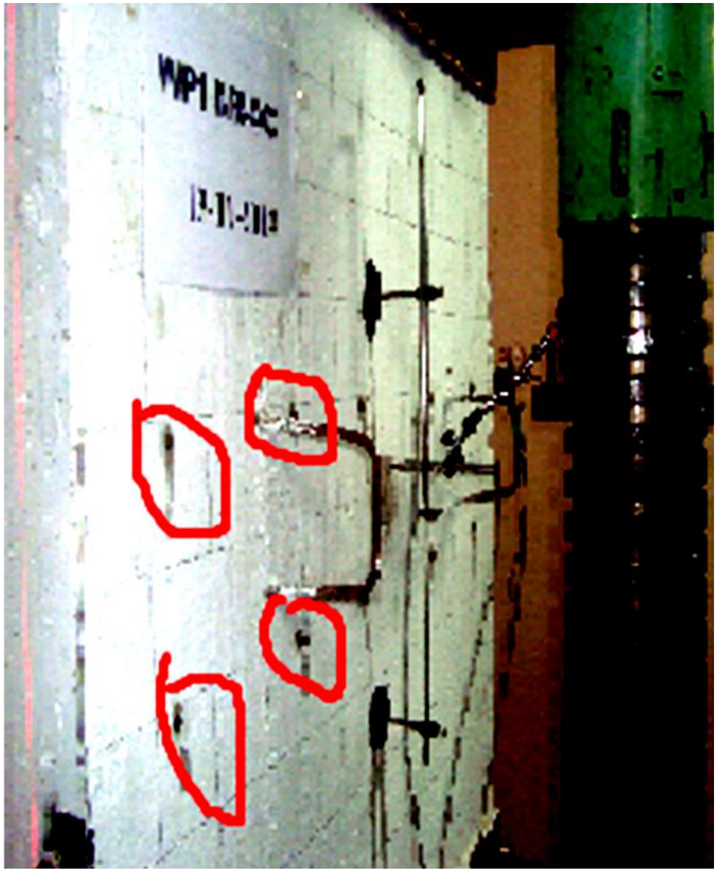


LVDTs position for wall panel

Instrumentation and Measurements

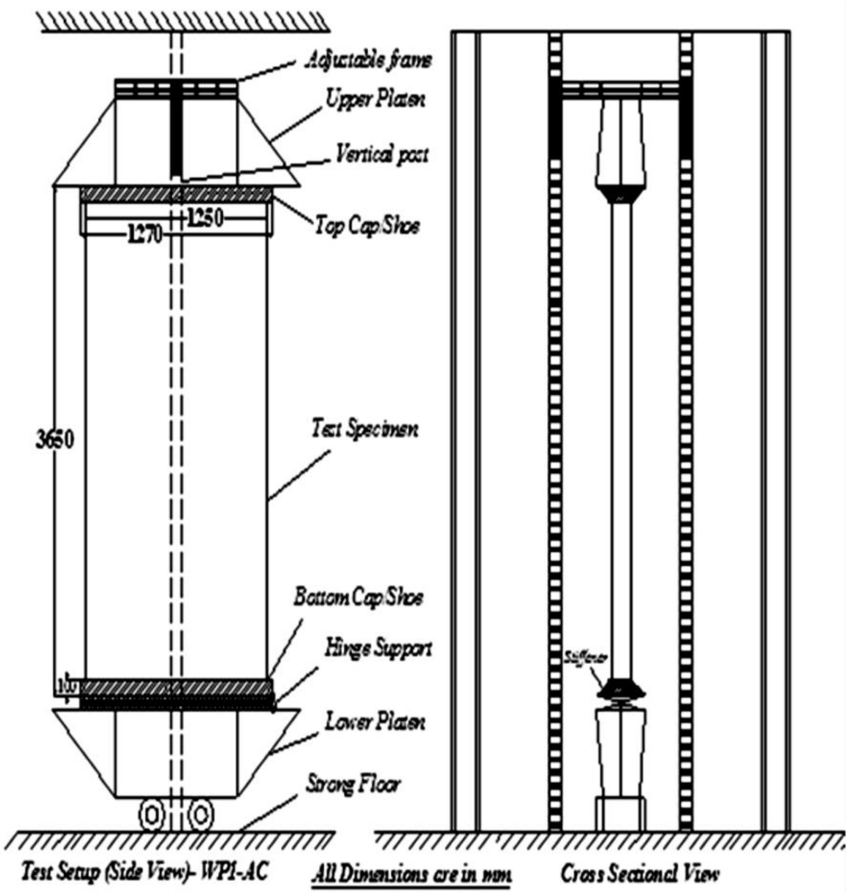


Electric strain gauge



DEMEC pellets

Test setup



(a)

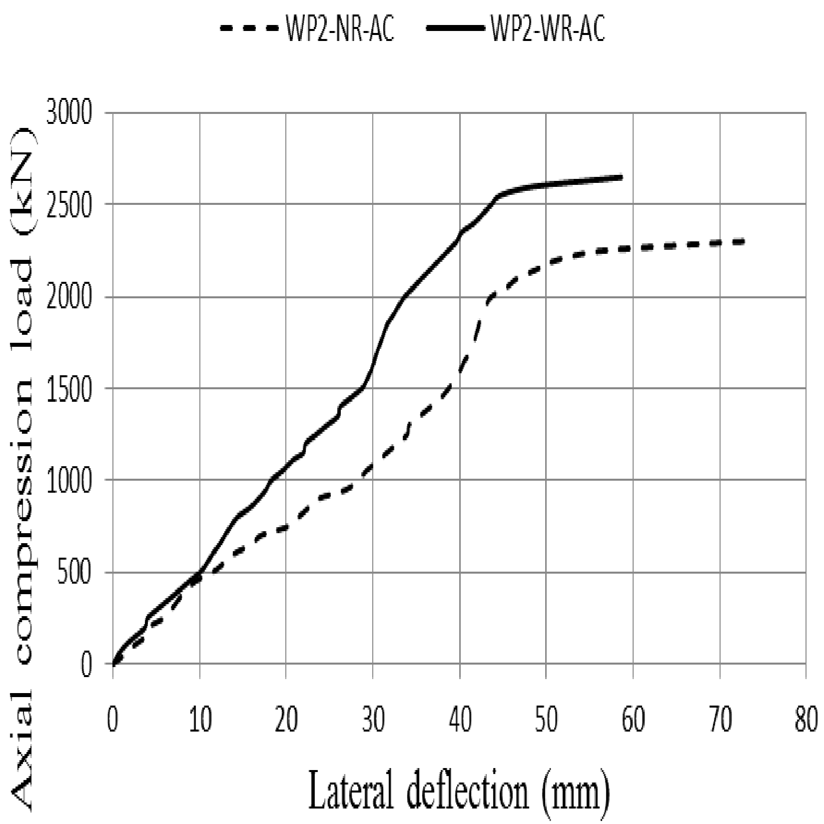
(b)

Plain wall panel (a) Schematic diagram (b) Test setup

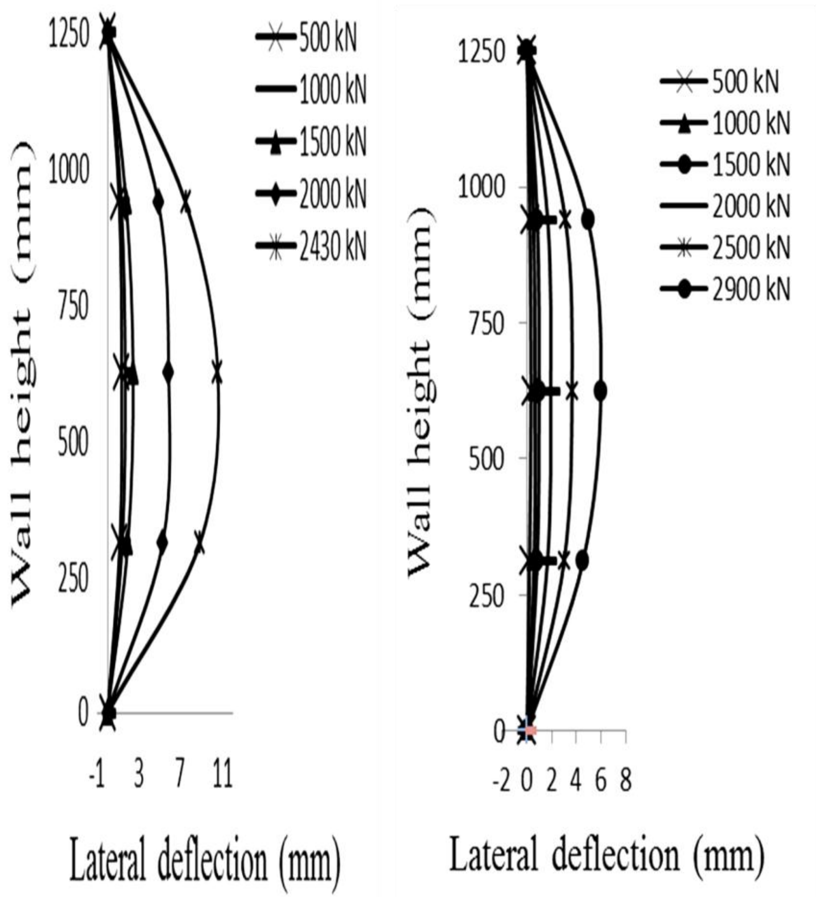
Testing Procedure

- *Panel was placed in the loading frame in the correct position ensuring the end conditions.*
- *Wall was then white washed to mark the crack pattern. LVDTs were arranged at their fixed locations.*
- *Instruments were checked and adjusted properly, before applying the load.*
- *A small load of around 10 kN was first applied to make sure that all the instruments were functioning.*
- *Load is then increased gradually with an increment of 50 kN for slender walls and 100 kN for squat walls until the failure.*
- *At each load increment, strains in concrete, steel reinforcement and steel connectors were recorded by a Data Logger with catmanEasy supported by HBM connected to a computer.*
- *Crack pattern was also noted at each load increment. Cracks were marked on surface of the panel corresponding to the load.*

Load deflection response

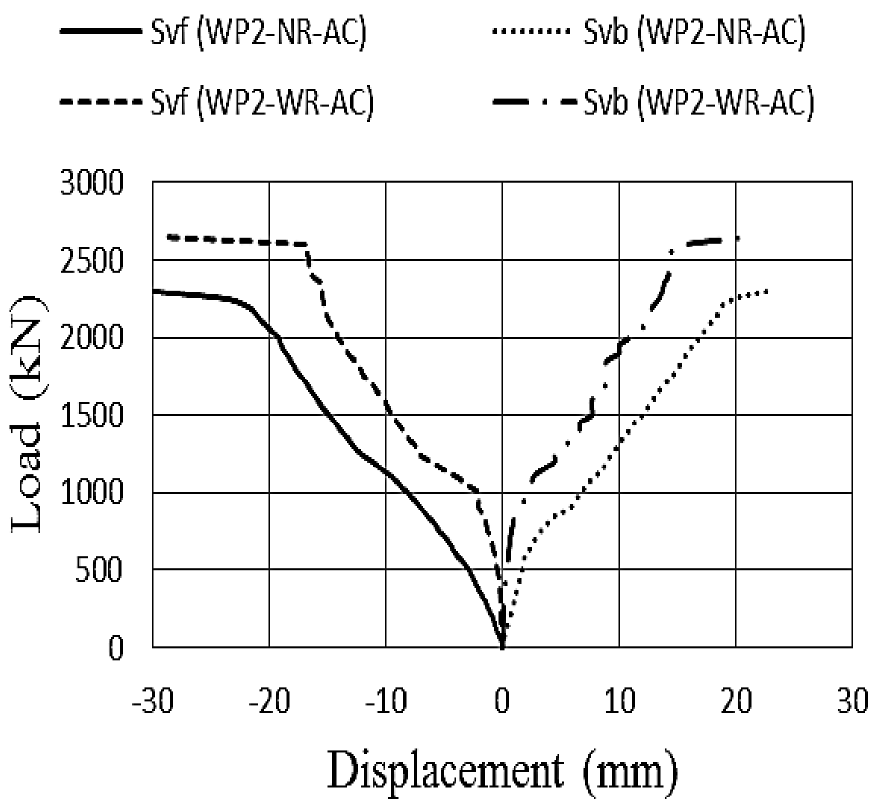


Axial load vs. lateral deflection at mid-height of plain walls.

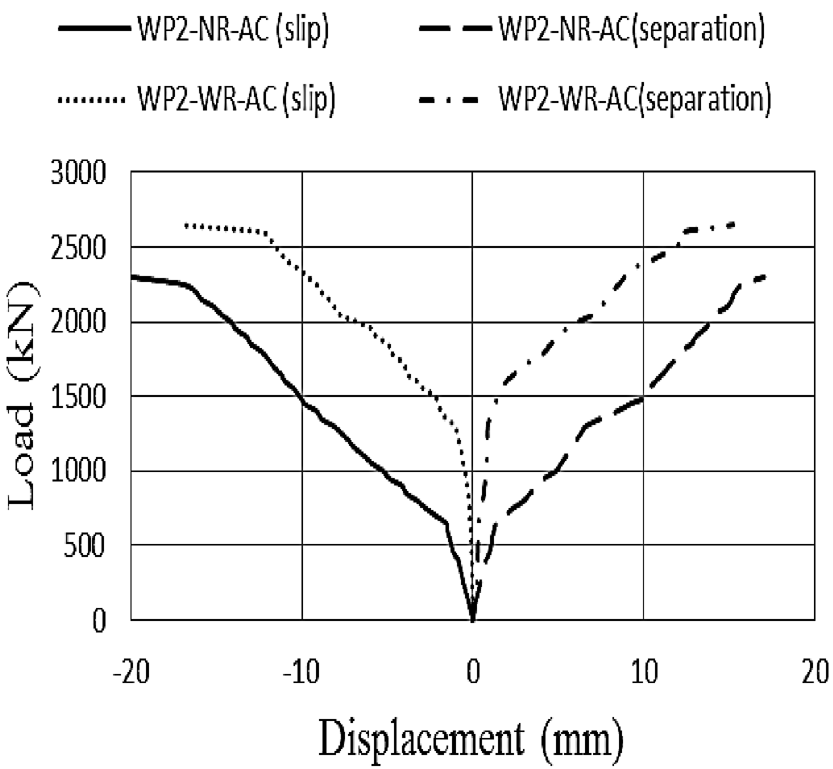


(a) WP1-NR-AC, (b) WP1-WR-AC
Lateral deflection of wall panels.

Load deflection response

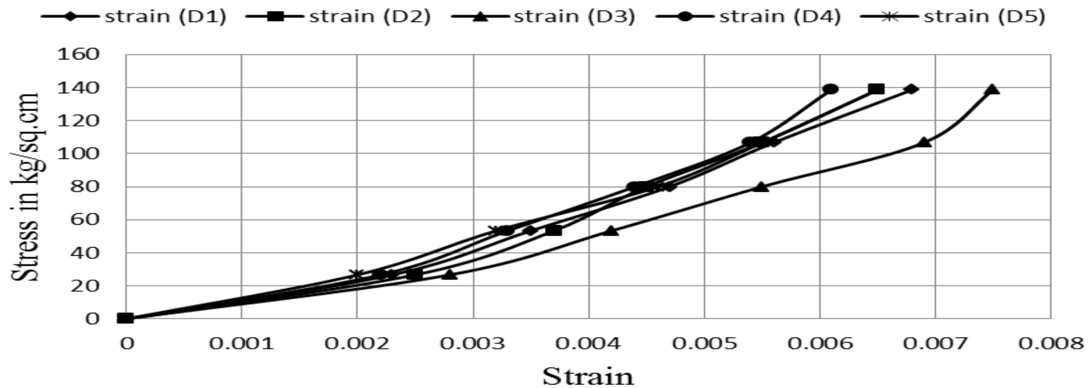


Vertical deformation of concrete layers in axial compression (slender wall)

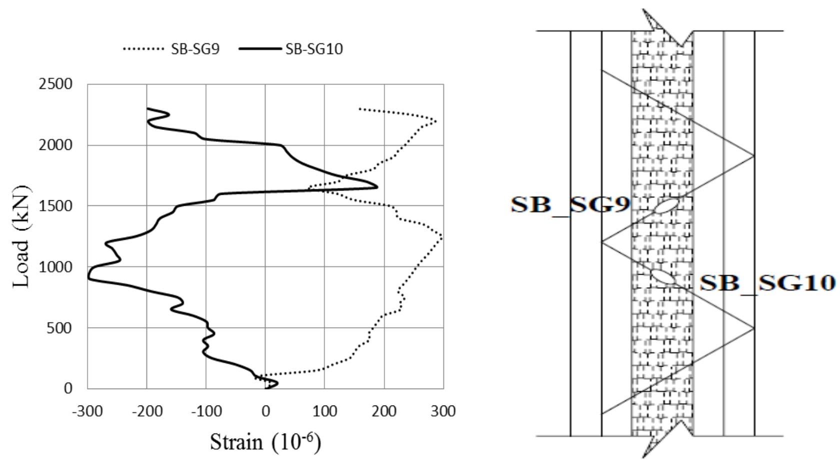


Slip and separation of concrete layers under axial compression (slender wall).

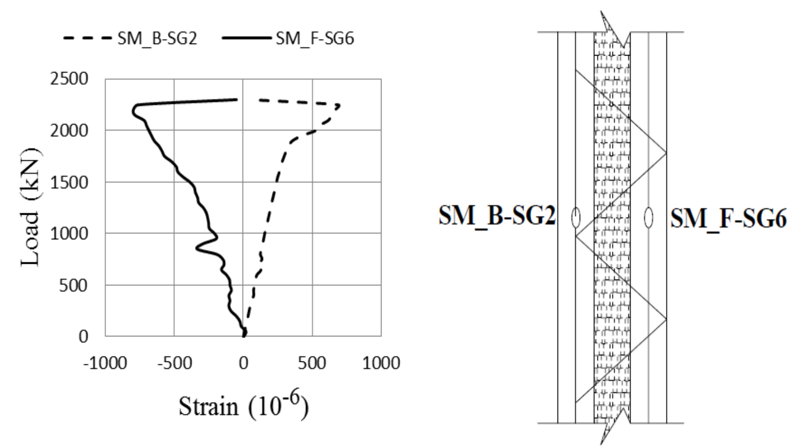
Strain characteristics



Axial stress vs. surface strain for the specimen WP1-WR-AC



Axial load vs. strain in steel (SB-SG9 and SB-SG10) at the bottom of WP2-NR-AC

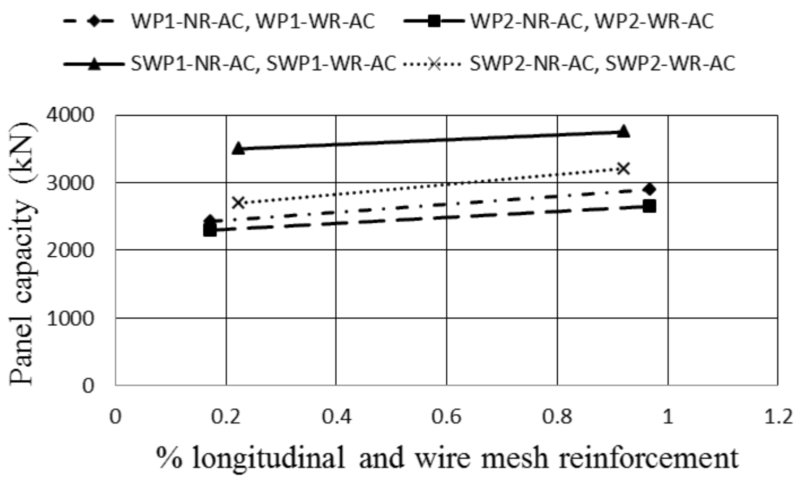


Axial load vs. strain in steel (SM_B-SG2 and SM_F-SG6) at mid height of WP2-NR-AC

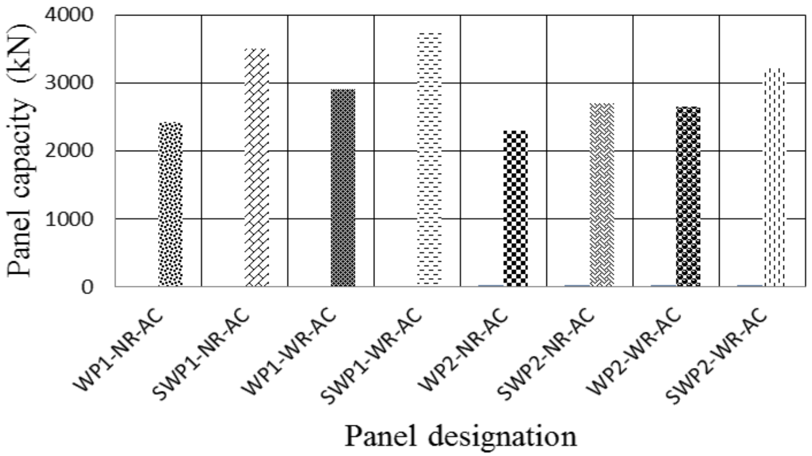
Crack patterns and failure mode

Figure showing failure of WP1-WR-AC

Figure showing failure of WP2-WR-AC



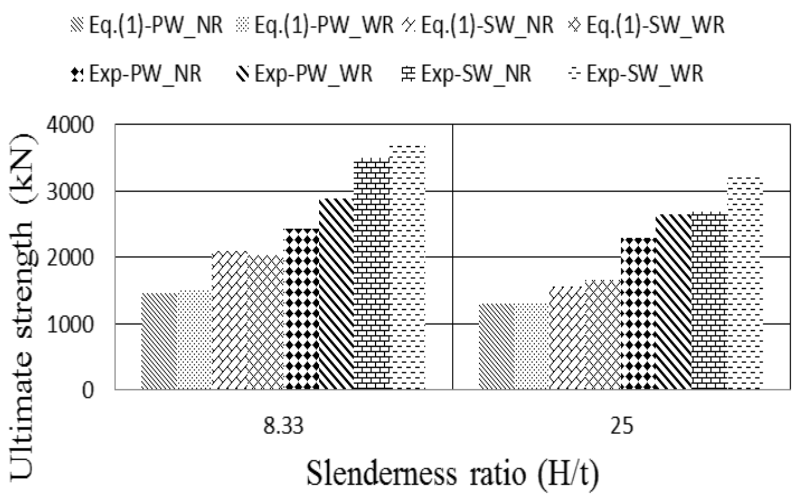
Influence of longitudinal reinforcement



Influence of stiffening elements

Panel Designation	H/t	Ultimate load (kN)	
		Eq.(1)	Experiment
WP1-NR-AC	8.33	1470	2430
WP1-WR-AC	8.33	1511	2900
WP2-NR-AC	25	1317	2300
WP2-WR-AC	25	1305	2650
SWP1-NR-AC	8.33	2091	3500
SWP1-WR-AC	8.33	2044	3750
SWP2-NR-AC	25	1560	2700
SWP2-WR-AC	25	1671	3210

Comparison of design strengths



Comparison of design strengths

CONCLUSION

- *Influence of longitudinal reinforcement and stiffeners in 3D wall panels has been observed to be significant on the strength and modes of failure.*
- *Cracks were formed in only one layer of concrete or on both.*
- *A violent failure occurred in all squat walls due to crushing, whereas in slender walls due to buckling at mid-height.*
- *First cracks were formed at loads in the range of 51-80% of the ultimate loads.*
- *Strength of wall panels decreases nonlinearly with increase in the slenderness ratio.*
- *Strength reduction was 22.5% in SW_NR when the slenderness ratio was increased from 8.33 to 25.*
- *Vertical cracks were also observed at the junction of stiffener and wall in SWP1-NR-AC.*
- *Strains in steel connectors remained well within the yield limit.*
- *The panels behaved as composite members till failure.*

THANK YOU